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Using Herbicides for Reforestation in the Southwest

L. J. Heidmann

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L. J. Heidmann, Principal Silviculturist
Rocky Mountain Forest and Range Experiment Station[1]

ABSTRACT

Site preparation is essential to successfully regenerate conifer stands in the Southwest. Selection of herbicides used to prepare regeneration sites, calibration of equipment, methods of application, and safety are discussed.

FOREWORD

This guide was prepared to assist practicing foresters in the use of herbicides for preparing regeneration areas and releasing trees from herbaceous competition. As such, it does not answer all questions concerning the safe and effective use of herbicides. For information not covered by the guide, the reader is referred to the appropriate state agency which oversees the registration and use of pesticides:

Arizona
State Chemist
P.O. Box 1586
Mesa, Arizona 85201
(602) 833-5442

Colorado
Colorado Department of Agriculture
Division of Plant Industry, Pesticide Inspection
State Services Building
Denver, Colorado
(303) 839-2838

New Mexico
Office of Pesticide Management
New Mexico Department of Agriculture
Box 3AQ
Las Cruces, New Mexico 88003
(505) 646-2133

[1] *Headquarters is in Fort Collins, in cooperation with Colorado State University. Information reported here was prepared at the Station's Research Work Unit at Flagstaff, in cooperation with Northern Arizona University.*

Using Herbicides for Reforestation in the Southwest

L. J. Heidmann

INTRODUCTION

To establish most species of trees, some form of site preparation is essential. This is especially true in the southwestern United States, where competing vegetation and deficient and erratic precipitation can effectively prevent establishment of ponderosa pine. Essentially there are three methods of site preparation—chemical, mechanical, and fire. This report discusses techniques for using herbicides to prepare regeneration sites.

Although herbicides are not the solution to all site preparation problems in the Southwest, the use of chemicals has some advantages over other site preparation methods. On areas with dense stands of perennial grass, the mulching effect of the dead vegetation retains more moisture (fig. 1) (Heidmann 1969). Also, because topsoil is not disturbed, the potential for erosion is reduced on steep slopes. Herbicides also may be preferred on terrain unsuitable for mechanical equipment. Some disadvantages of herbicides are that mineral soil is not exposed for natural regeneration, and herbicides may harm people and the environment if not used correctly. It is also sometimes difficult to plant trees on sites where vegetation has been killed by herbicides, especially in heavy brush stands where movement may be limited. An additional disadvantage may be increased fuel loadings and resulting increased fire danger.

Before using any pesticide, the user should have at least an elementary knowledge of laws and regulations pertaining to their use. The term pesticide refers to any compound for controlling unwanted vegetation, insects, rodents, etc. Herbicides are chemicals used solely for controlling unwanted vegetation, commonly termed weeds.

Federal Laws

In 1910, the first federal law pertaining to pesticides, the Federal Insecticide Act, was enacted. In those days, few pesticides, except for inorganic compounds, were available. Following World War II, with the advent of chlorinated hydrocarbons, the number of pesticides increased greatly. In 1947, Congress passed the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This law empowered the USDA to require that manufacturers provide proof of the safety and efficacy of their products, and authorized the Agency to regulate the manufacture and consumer use of pesticides. In 1970, the Environmental Protection Agency (EPA) was created, assuming pesticide responsibility from the USDA. In 1978, FIFRA was amended to assign primary authority for pesticide use enforcement to individual states. Before enforcement authority can legally be transferred by the EPA, however, states must indicate that their regulatory methods will meet or exceed federal requirements.

It is important, therefore, that anyone planning to use herbicides or other pesticides be familiar not only with federal laws, but also with state laws and regulations. In Arizona, for example, all persons working as pesti-

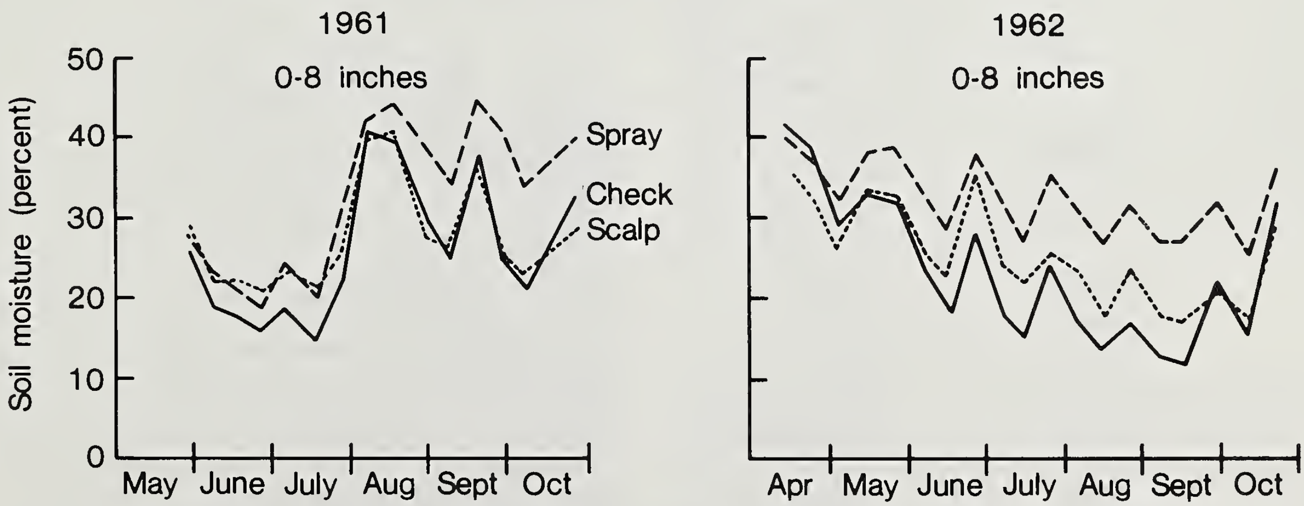

Figure 1.—Percent moisture for the 0- to 8-inch soil depth, under three site preparation treatments, at Wing Mountain, Arizona, in 1961 and 1962.

cide advisors must pass a written general examination on safety, laws, rules, and regulations. In addition, advisors must pass an examination in their particular area of interest. Certification is required to apply restricted use pesticides.

Pesticide Labeling

Anyone working with pesticides should be familiar with pesticide labeling. Labeling refers to the labels and other written, printed, or graphic material which accompanies the pesticide container. The label actually attached to the container may or may not contain all of the necessary information regarding use of the product.

Pesticide labels contain information essential for the safe, effective, and legal use of the product. The label contains the common and chemical names, susceptible species, mixing procedures, season of application, rates, types of equipment to use, the EPA registration number, warnings, and other pertinent information. It is essential that the user read and understand the information on the label before using the product. It is illegal to use any pesticide in a manner inconsistent with its labeling. (Table 1 lists chemical and trade names for some common herbicides used in forestry.)[2]

Formulations

Liquid herbicides include emulsifiable concentrates and solutions. Dry materials commonly used are dusts, granules, and soluble and wettable powders. It is important to determine the formulation to be used, because it may dictate the choice of equipment. For example, wettable powders are finely divided particles which form a suspension when mixed with water. The spray mixture must be agitated constantly during use; therefore, a sprayer with this capability is required.

[2]Mention of a trademark or proprietary product name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

CLASSIFICATION OF HERBICIDES

General and Restricted Use

Herbicides may be classified in several ways. The 1972 amendment to FIFRA empowered the EPA to classify all herbicides as general or restricted use. The most important restricted use herbicides for forestry are picloram and paraquat, which may be used only by or under supervision of certified personnel. Some herbicides have been removed from the forestry market (e.g., 2,4,5-T). To determine whether an herbicide is approved for use in a particular area, consult with the proper state agency.

Plant Responses

Herbicides can also be classified as selective and nonselective. The term "selective" implies that target plants are killed, but desirable plants are not. This may or may not be true. Nonselective herbicides are intended to kill all of the vegetation on the site. Certain herbicides, however, may fit into both categories. Simazine, for example, may be used selectively to kill unwanted vegetation in citrus orchards and nonselectively to control weeds along fences and on other noncrop sites. Usually, the difference between selectivity and nonselectivity is in the dosage, the placement, and the timing. Some herbicides may be highly selective in pine plantations at rates of 5 pounds per acre, whereas 50 pounds per acre will kill all vegetation present.

Table 1.—Trade and chemical names of some commonly used forestry herbicides

Trade name	Common chemical name of active ingredient	Chemical name
Dowpon M	Dalapon	2,2-dichloropropionic acid
Aatrex 80 W	Atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
Esteron 4	2,4-D	2,4-dichlorophenoxyacetic acid
Roundup	Glyphosate	isopropylamine salt of N-(phosphonomethyl) glycine
Milogard	Propazine	2-chloro-4-,6-bis (isopropylamino)-s-triazine
Princep	Simazine	2-chloro-4,6-bis(ethylamino)-s-triazine
Asulox	Asulam	methyl sulfanilylcarbamate
Goal	Oxyfluorfen	2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene
Modown	Bifenox	methyl 5-(2′,4′-dichlorophenoxy)-2-nitrobenzoate
Spike	Tebuthiuron	1-(5-tert-butyl-1,3,4-thiadiazol-2-yl)-1,3-dimethylurea
Tordon	Picloram	4-amino-3,5,6-trichloro-picolinic acid
Velpar	Hexazinone	3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5,-triazine-2,4(1H,3H)dione

Selective and nonselective herbicides work either through the foliage or the roots. Foliage-applied herbicides act in two ways. Systemic herbicides are absorbed by the foliage and translocated within the plant's vascular system to the site of action. Because the herbicide is translocated throughout the entire plant, the entire plant can be killed, although some systemics do not enter the roots. Systemic herbicides generally must be applied when the plant is actively growing and the foliage is green. Contact herbicides kill only the plant parts actually contacted and have little movement within the plant. Contact herbicides, therefore, must be applied in enough carrier (usually water) to adequately cover the foliage. Dalapon and 2,4-D are examples of foliage-applied systemic herbicides which are selective; amitrole is nonselective. Bromoxynil is a selective foliage-applied contact herbicide; paraquat is a nonselective one.

Soil-applied herbicides must be moved into the soil by water or mechanical incorporation. Most soil-applied herbicides used in forestry are known as preemergents. That is, they are applied to the soil in the fall or winter and kill grasses or forbs after the seeds germinate, the following spring and summer. Atrazine is a selective soil-applied herbicide which is translocated in the plant; trifluralin is a selective soil-applied herbicide which is generally nonmobile. An example of a nonselective soil-applied herbicide is methyl bromide, which is used as a soil sterilant.

DOING THE JOB

Selecting the Herbicide

The herbicide selected for a particular weed and crop problem should be recommended for the specific pest by proper authorities. Safety should be considered also. For example, an herbicide may be available in both a granular and wettable powder form. If drift is a matter of concern, it may be advisable to use the granular material.

If an area to be planted is devoid of trees and covered with a mixture of perennial grasses, sedges, and forbs, then a nonselective herbicide, such as glyphosate (Roundup), or a mixture of the selective herbicides dalapon and atrazine may be used. If advanced regeneration is present, glyphosate should not be used unless it can be applied as a directed spray, avoiding conifers. Dalapon usually can be broadcast sprayed where conifers are present, if the trees are several years old and mild surfactants (wetting agents) are used. However, dalapon may damage ponderosa pine and other conifers, under certain situations. Work conducted in the Pacific Northwest has shown that combinations of dalapon and atrazine are more effective in controlling grasses and forbs than either herbicide alone, and are less toxic to conifers (Newton and Overton 1973, Dimock and Collard 1981). Asulam is quite effective on forbs and bracken fern. Ferns are usually found on moister sites, typical of mixed conifer and spruce-fir forests. Two newer herbicides, oxyfluorfen and bifenox, are quite effective on forbs and annual grasses. At present, however, these herbicides are registered only for nursery use.

Control of brush species, such as New Mexican locust and Gambel oak, with herbicides is difficult because of the tendency for these species to sprout. Prior to 1979, the most widely used herbicide for brush control was 2,4,5-T. The use of this herbicide is now mainly suspended. There are herbicides, such as picloram, which will control brush, but they persist in the soil for extended periods of time, thus making it difficult to plant pine trees. It may be possible to control brush by burning it and spraying the sprouts when they appear. Two of the newer herbicides which hold promise for brush control are tebuthiuron and hexazinone. Tebuthiuron, however, can be applied in Arizona, only by representatives of the manufacturer (Elanco). Table 2 lists some suggested herbicides to use in various cover types.

Factors Affecting Rates

The amount of herbicide to use varies with vegetation being controlled, soil texture, organic matter, and precipitation. An elementary knowledge of soils is helpful in planning herbicide projects. In a clay soil, for example, more herbicide is necessary to control the vegetation than on a sandy soil (table 3), because cations in the herbicidal solution bind to negatively charged clay soil particles. In addition, finer textured soils (silts and clays) generally have greater microbial activity because of increased amounts of organic matter, which results in a faster breakdown of the herbicide. In sandy soils, there is less microbial activity and, consequently, less breakdown of the herbicide. Herbicides leach from sandy soil faster than from clay, but if precipitation is deficient after herbicides are applied, they may remain in the soil for a considerable period of time without breaking down. If this is the case, herbicides such as dalapon, which are usually nontoxic to conifers, may be absorbed by the tree roots and translocated to the tops (fig. 2). Herbicide rates, therefore, should be adjusted accordingly to suit the soil texture. As an example, atrazine is used at rates of 10 pounds of active ingredient or more for controlling forbs and annual grasses on basalt-derived soils which are high in silt and clay content. On agricultural areas in the Southwest, where soils often are quite sandy, atrazine is used at rates of 1-2 pounds per acre. Information on rates for various soils is on the herbicide label.

Adjuvants and Surfactants

Materials added to an herbicide to improve its action are called adjuvants. They may already be included in the product or may be added separately before use. Adjuvants include surfactants, emulsifiers, thickening or sticking agents, penetrating agents, and dispersing agents. They may greatly increase the effectiveness of an herbicide but also reduce its selectivity.

Table 2.—Suggested herbicides for preparing coniferous regeneration sites in the Southwest

Predominant cover	Herbicide (common name)	Application rate (pounds ai/acre)[a]	Season of application or foliage condition
Perennial grass	Dalapon	5-10	actively growing
	Glyphosate	2-4	actively growing
Perennial grass and forbs	Dalapon	5-10	actively growing
	plus Atrazine	4-10	
	Glyphosate	2-4	actively growing
Perennial grass and advance regeneration or, perennial grass, forbs, and advance regeneration	Dalapon	5-10	actively growing
	plus Atrazine	4-10	
	Glyphosate	2-4[b]	actively growing
Annual grass and forbs, or forbs, annual grass and advance regeneration	Atrazine	4-10	fall, winter
	Simazine	4-10	fall, winter
	Asulam	2-4	summer
	Oxyfluorfen[c]	1/2-1	spring, summer
	Bifenox[c]	2-4	spring, summer
Bracken fern	Asulam	3-7	summer
Brush	Hexazinone	1-2	summer
	Picloram	75-85[d]	early spring
	Tebuthiuron	1/2-2	summer

[a]*Rate will depend upon species of vegetation and soil type. Consult label for more detailed information.*
[b]*Do not use glyphosate in newly established plantations. Underspray larger trees being sure to avoid conifer foliage.*
[c]*Nursery use only.*
[d]*Pounds of product (Tordon K pellets). Restricted use herbicide.*

Table 3.—Soil characteristics for various soil types

Characteristic	Sand	Loam	Clay	Peat/Muck
Absorption capacity	very low	low	moderate	very high
Herbicide leachability	rapid and deep	moderate	low	almost none
Relative herbicide activity	high	moderate	moderate to low	very low

Figure 2.—Example of herbicide damage in larger trees. Dalapon was applied the preceding summer, but because of dry winter conditions and a sandy soil, the herbicide did not break down. Left photo was taken in June 1977, about 1 year after treatment. Right photo, showing recovery, was taken in November 1977.

Surfactants accentuate the emulsifying, spreading, or wetting properties of a spray solution at a surface. They work by reducing the surface tension of water thus allowing the solution to flow over or wet the plant leaf more thoroughly. The result is that more of the herbicide is able to enter the plant.

Surfactants can be grouped into three categories according to electrical charge:

Type	Charge
Anionic	Negative
Cationic	Positive
Nonionic	Neutral, no charge

The nonionic surfactants are most commonly used in agricultural sprays, because they are relatively unaffected by water hardness.

Application Methods and Equipment

Ground Rigs

Commercial sprayers used in agriculture have essentially the same design (fig. 3). The basic components are a tank, pump, hoses, pressure regulator, and a boom with nozzles. To resist the corrosive effect of most agricultural chemicals, the tank should be constructed of stainless steel or fiberglass-reinforced plastic. Agitation is necessary in most spray tanks. Bypass, or hydraulic agitation is adequate for compounds forming true solutions or for emulsifiable formulations. High pressure jet or mechanical paddle agitation is essential to maintain adequate mixing of wettable powders, flowable liquid concentrates, and emulsions containing much oil.

The pump provides the necessary pressure to force the solution through the hoses and nozzles. There are several types of pumps, but the most versatile is the piston pump. It operates over a wide pressure range, is resistant to wear from abrasive materials—such as wettable powders, and has a long service life. The main disadvantage is a low flow rate, which means that the tank must have mechanical agitation.

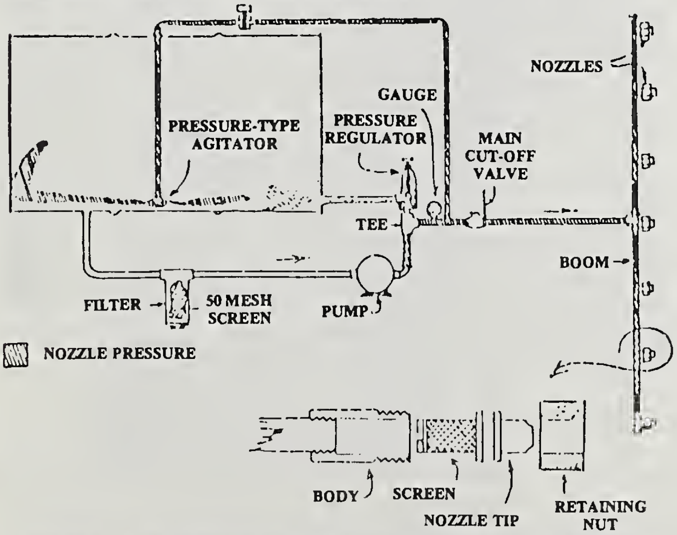

Figure 3.—Schematic drawing of basic components of a sprayer.

A pressure regulator is needed to maintain a constant pressure in the system to keep the amount of material applied uniform. Excess solution is routed back from the pressure regulator relief valve into the spray tank. Control valves are needed between the pressure regulator and the boom.

Hoses and lines must be able to withstand the chemicals or the carriers used, especially petroleum solvents. A coarse strainer should be used for filling the tank. Inline strainers between the tank and the pump, as well as behind each nozzle, should be used. Screens should not be finer than 50 mesh for wettable powders, but can be 100 mesh for emulsions and true solutions. Booms can vary from a few feet to more than 70 feet in length. However, to get uniform coverage, the pressure at each nozzle needs to be the same, and the height of each nozzle above the ground needs to be uniform. For wide swaths, boomless jet nozzles which cover strips up to 60 feet wide may be used (fig. 4). The most common jets and nozzles used in commercial sprayers give flat, fan shaped or conical patterns.

Aerial Application

On areas larger than 100 acres, it may be less expensive to apply herbicides by air (fig. 5). Much of the cost, however, depends on deadhead time (time involved in flying from the base to the spraying site). If the aircraft can land ajacent to the site, costs will be less than if several minutes are required to return to the base for each load.

Aerial spraying is best suited to level terrain free of standing obstacles. In much of the Southwest, fixed wing aircraft cannot be used because of steep slopes and canyons. Helicopters are effective over much of this terrain but are more expensive to operate. Aerial application gives rapid coverage of the area and thus may be less expensive. However, there are some disadvantages to aerial application. Drift is more of a problem, and hazards to the applicator are greater than to operators of ground equipment because of terrain and standing obstacles.

Backpack or Hand-held Equipment

For spraying smaller areas or doing "touchup" spraying, different types of smaller sprayers are available. The micron sprayer (fig. 6) is ideal for spraying small acreages. It consists of a battery-operated motor which spins a small disk, producing very small uniform droplets. The tank only holds 2.5 liters of solution, but because of the very fine spray applied, this is sufficient to cover approximately 0.6 acre. One person can spray several acres a day with a micron sprayer. A disadvantage of the micron sprayer is that it puts out a circular spray pattern about 5 feet in diameter. It is sometimes difficult to spray around and between individual trees with this type spray pattern. Another sprayer which uses more material but is useful for spraying small areas is typified by the Solo model 425 backpack

pressure sprayer (fig. 7). With a flat spray nozzle, a spray solution can be directed right up to the base of small seedlings without getting material on the foliage. This sprayer, however, holds only 3 gallons of solution, which limits its usefulness to small areas.

The backpack mistblower is another sprayer suited for smaller spraying jobs (fig. 8). Because of the small droplet size, about 8 to 10 gallons of solution will treat 1 acre. A major disadvantage is that because of the weight and the vibration from the running motor, it is difficult for one individual to work with the mistblower for long periods of time. It is much more tiring than the micron sprayer or the backpack pressure sprayer.

Granular Application

Many herbicides are available in granular form and are applied dry, generally to control unwanted trees and brush. Often, the material may be broadcast under individual trees by hand. When applying granular material in this manner, the applicator must be certain to wear rubber gloves and a respirator. Granular material also may be broadcast with "cyclone seeders" or may be applied by air.

Figure 4.—Truck mounted pressure sprayer with a boomless jet capable of spraying a 50- to 60-foot swath.

Figure 5.—Large acreages can be sprayed most economically by aircraft.

Figure 6.—The "Herbi" micron sprayer. The 2.5-liter bottle contains enough spray solution to cover about 0.6 acre.

Mixing the Spray Solution

As an example, assume the task is to spray a 50-acre parcel which has a dense cover of Arizona fescue and mountain muhly. Previous experience has shown that a rate of 5 pounds of active ingredient (a.i.) per acre of the magnesium salt of dalapon (Dowpon M) will effectively control these two species on a clay loam soil. In some instances, when perennial grasses are controlled, a site may be invaded by forbs and annual grasses the following year. Because of this, a preemergent herbicide should be added to the spray mixture. Based on previous research, 5 to 10 pounds a.i. of atrazine or simazine per acre probably will be needed. Also, 40 gallons of spray solution per acre is necessary to provide good coverage of the grass species, if the material is applied with ground equipment. The solution can be prepared as follows:

Dalapon Five pounds a.i. of the magnesium salt per acre sprayed are needed. Dowpon M is 84.5% active ingredient; therefore, divide 5 pounds by 0.845, resulting in 5.92 pounds (5 pounds 14.7 ounces) of the product (Dowpon M) needed per acre.

Atrazine Ten pounds a.i. atrazine per acre is needed. Using commercial Aatrex 80-W, which contains 80% a.i., divide 10 by 0.8 to determine that 12.5 pounds (12 pounds 8 ounces) of the product is required per acre.

Surfactant The average amount of surfactant used in most herbicide sprays is approximately 0.125% to 0.5% (1 pint to 2 quarts per 100 gallons of spray solution). The maximum effect obtained with a given concentration will vary with surfactant and herbicide. Phenoxy-type herbicides (e.g., water soluble amine of 2,4-D) generally show maximum increases around 0.2% to 0.5%, while other types of foliar-applied herbicides (dalapon, paraquat, amitrole, etc.) often show maximum effects from 0.5% to 1.0%. For the surfactant, 0.5% of Tween 20 will be used here. This means that 0.2 gallon (758 cc) of Tween is needed for each 40 gallons of solution.

Figure 7.—A backpack pressure sprayer suitable for treating small areas.

Figure 8.—A backpack mistblower. The tank holds enough solution to spray approximately one-third acre.

The herbicides and wetting agent are added to water to give a total solution of 40 gallons per acre sprayed. On the 50-acre plot, the following will be needed:

296 pounds of dalapon—(5.92 pounds product per acre × 50 acres)
625 pounds of atrazine—(12.5 pounds product per acre × 50 acres)
10 gallons of Tween 20—(50 acres × 40 gallons per acre × 0.05%)
2,000 gallons of water—(50 acres at 40 gallons per acre).

Calibration

Calibration ensures that the proper amount of spray solution is applied to the site. There are three acceptable methods for calibrating sprayers: by varying the speed of the sprayer, by varying the pressure, and by varying the nozzle size.

Adjusting the Pressure

Beginning with the assumptions that experience indicates the best speed for driving the spray rig is 3 miles per hour (264 feet per minute), and that the available equipment is a boomless jet which gives a spray width of approximately 60 feet, the pressure needed can be calculated. In 1 minute, 15,840 square feet will be covered (264 feet × 60 feet). To spray 1 acre, therefore, will take 2 minutes 45 seconds (43,560 square feet/15,840 square feet = 2.75 minutes = 2 minutes 45 seconds). Because it is necessary to apply 40 gallons of solution per acre, a discharge rate of 14.55 gallons per minute (40 gallons/2.75 minutes = 14.55 gallons) is needed. To find out the actual discharge rate of the equipment being used, fill the spray tank with clean water and turn on the sprayer. Collect and measure the amount of water discharged in a specified period of time (e.g., 30 seconds). Do this at least three times to get an average figure. It is found that the sprayer is discharging 10

gallons per minute. Because a discharge rate of 14.55 gallons per minute is needed, it is necessary to adjust the pressure regulator until the proper discharge is attained. Changing the pressure is not advisable for making gross changes in discharge, however, because a pressure change may change the nozzle pattern and droplet size. Pressure must be increased four times to double the output.

Adjusting the Speed

In the above illustration, the sprayer, before adjustments, delivered 10 gallons per minute which would require 4 minutes to spray each acre (40 gallons/10 gallons per minute). The sprayer will need to cover 10,890 square feet per minute at this discharge rate (43,560 square feet/4 minutes). Because the swath width is fixed at 60 feet (for this particular boomless jet), it is necessary to travel 181.5 feet per minute to cover 10,890 square feet (10,890/60). This is a speed of slightly more than 2 miles per hour. A slower speed means more material delivered.

Changing Nozzle Tips

The amount of spray discharged is related to the size of the opening in nozzle tip. A larger opening will deliver more spray solution at the same speed and pressure than a smaller one. A TeeJet 8001E spray tip, for example, delivers 0.10 gallon per minute at 40 pounds pressure, while a 8015E tip delivers 1.50 gallons per minute at the same pressure. Adjusting nozzle tips is the best method for making gross changes in the delivery rate.

When using hand-held equipment for spraying small areas, it is difficult to apply solutions uniformly, because the sprayer may be held in one location for too long or too short a period, or the speed at which the person walks may be uneven. To overcome this problem, it is necessary to accurately calibrate the sprayer and to make sure that application is uniform. The applicator should determine the specific distance to be covered in a specified period of time to apply the desired amount of material. After this has been determined, practice by walking a specified distance in a specified period of time with the sprayer. If, for example, it has been decided that a strip 10 feet wide and 100 feet long has to be covered in 2 minutes with a mistblower to apply dalapon at a rate of 5 pounds of active ingredient per acre, the applicator should practice walking this strip with the sprayer until the timing is correct.

SPRAYING CONDITIONS

Spraying should not be attempted in windy conditions. Usually for ground spraying, the winds should be less than 10 miles per hour and for aerial application less than 5 miles per hour. Spraying conditions are usually best in early morning or late afternoon and evening, when winds tend to be moderate. In addition, at these times, stomata are more likely to be open, which enhances the uptake of herbicides. Systemic herbicides usually are less effective when plants are under stress, because the stomata are likely to be closed.

The most appropriate time to apply systemic herbicides in the Southwest is during the summer rainy season. Herbicides such as dalapon may be applied on days when it rains, if the spraying can be done a couple of hours before rains begin.

SAFETY IN USING HERBICIDES[3]

Safety in using herbicides is related chiefly to effects on humans, nontarget plants, and other life forms.

Human Safety

Herbicides are classified into four toxicity classes, as determined by the LD_{50} values, which are expressed in milligrams of orally administered herbicide per kilogram of body weight that results in killing 50% of test animals. Herbicides may also be toxic if inhaled or absorbed through the skin. Table 4 lists the four toxicity classes, along with some examples and the amount of material considered to be a lethal dose to a 160-pound person.

Herbicides are relatively low in toxicity to humans compared to other pesticides. Most herbicides present no particular hazard when handled with reasonable care and applied in accordance with registered and recommended uses. One exception, however, is methyl bromide, a highly poisonous gas widely used as a soil fumigant in tree nurseries. Specific precautions and handling instructions on herbicide labels should always be followed.

Good handling habits must be encouraged and practiced with all pesticides. Personnel should be trained and supervised to prevent unnecessary exposure. Specific allowable herbicide residues (tolerances) are established by EPA. These residue tolerances are premised on the protection of human welfare. Registered herbicides and recommended application rates should be strictly observed to avoid the possibility of excessive (illegal) residues. Spray drift from one crop to another or from noncrop areas to crop areas should be avoided to prevent illegal residue and/or crop injury.

Protection of Nontarget Plants

The greatest hazard associated with herbicides is the phytotoxic effect on nontarget plants caused by incorrect or inaccurate application. Spray drift in either particle or vapor form, soil contamination resulting in subsequent root uptake by nontarget plants, excessive

[3]*Taken from Study Guide for Agricultural Pest Control Advisors. William Finch, editor. Arizona Agricultural Chemicals Association, Phoenix (Revised 1980).*

Table 4.—Pesticide toxicity classes and LD_{50} values for some common materials

Toxicity Class	LD_{50}	Required on label	Examples	LD_{50}	Amount required to kill 160-pound individual	
	mg/kg			*mg/kg*	*gm*	*ounces*
Highly toxic	1-50	Danger, Poison, Skull and Crossbones KEEP OUT OF REACH OF CHILDREN	Methyl bromide	35	2.54	0.09
Moderately toxic	50-500	Warning! KEEP OUT OF REACH OF CHILDREN	2,4-D	300	21.77	0.77
				1,000	72.57	2.56
			2,4,5-T	481	34.91	1.23
			Paraquat	157	11.39	0.40
Slightly toxic	500-5,000	Caution, KEEP OUT OF REACH OF CHILDREN	Aspirin	1,200	87.09	3.07
			Atrazine	3,000	217.72	7.68
			Cacodylic acid	830	60.24	2.12
Practically nontoxic	Above 5,000	KEEP OUT OF REACH OF CHILDREN	Simazine	5,000	362.87	12.80
			Picloram	8,200	595.11	20.99
			Dalapon	9,330	677.12	23.88
			Amitrole	24,600	1,785.33	62.98

soil persistence causing injury to subsequent crops, and sprayer contamination are to be avoided. Plant growth regulators (hormone-like herbicides) present the greatest visible hazard to nontarget plants, principally to the broad-leaved group, through drift. Herbicides may be subject to drift for considerable distances. Also, many herbicides are mobile in the soil. Therefore, caution should be exercised when spraying near bodies of water or on steep slopes.

Other Environmental Effects

At normally recommended rates, herbicides generally do not pose a hazard to livestock or wildlife. Herbicides are relatively nontoxic to honey bees. Herbicides often can be used to benefit wildlife by manipulating vegetation and improving habitat. Reduction of dense brush and aquatic weeds are examples of environmental enhancement.

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GLOSSARY[3]

Absorption—The process by which herbicides are taken into plants by roots or foliage (stomata, cuticle, etc.).

Acid equivalent (ae)—The theoretical yield of parent acid from the active ingredient content of a formulation.

Active ingredient (ai)—The agent in a product primarily responsible for the intended herbicidal effects, and which is shown as the active ingredient on the herbicide label.

Broadcast application—Herbicide treatment over an entire field area.

Brush control—Control of woody plants such as brambles, sprout clumps, shrubs, trees, and vines.

Carrier—A gas, liquid, or solid substance used to dilute or suspend an herbicide during its application.

Compatibility—Ability to mix in the formulation or in the spray tank for application in the same carrier without undesirably altering the separate characteristics or effects of components.

Concentration—The amount of active ingredient or herbicide equivalent in a quantity of diluent expressed as percent, lb/gal, ml/liter, etc.

Contact herbicide—An herbicide that causes localized injury to plant tissue with which it comes into contact.

Diluent—Any gas, liquid, or solid material used to reduce the concentration of an active ingredient in a formulation.

Directed application—Precise application to a specific area or plant organ, such as to a row or bed or to the leaves or stems of plants.

Emulsifiable concentrate (ec)—A single-phase liquid system, having the property of forming an emulsion when mixed with water.

Emulsifying agent (or emulsifier)—A substance which promotes the suspension of one liquid in another.

Emulsion—One liquid suspended as minute globules in another liquid (for example, oil dispersed in water).

Encapsulated formulation—Herbicide enclosed in capsules (or beads) of thin polyvinyl or other material, to control the rate of release of the chemical and extend the period of diffusion.

Flowable formulation—A two-phase concentrate that contains solid herbicide suspended in liquid which is capable of suspension in water.

Foliar application—Application of an herbicide to the leaves or foliage of plants.

Formulation—(1) An herbicide preparation supplied by a manufacturer for practical use; (2) the process, carried out by manufacturers, of preparing herbicides for practical use.

Fumigant—Chemical used in the form of a volatile liquid or gas to kill insects, nematodes, fungi, bacteria, seed, roots, rhizomes, or entire plants; usually applied in an enclosure of some kind or in the soil.

Granular—A dry formulation of herbicide and other components in discrete particles generally less than 10 mm^3 in size.

Herbaceous plant—A vascular plant that does not develop persistent woody tissues above ground.

Herbicide—A chemical used to control, suppress, or kill plants, or severely interrupt their normal growth processes.

Hormone—A growth-regulating substance occurring naturally in plants or animals; also refers to certain man-made or synthetic chemicals with growth-regulating activity. These, however, are more correctly called synthetic regulators; they are not hormones.

LD_{50}—The dose (quantity) of a chemical calculated to be lethal to 50% of the organisms in a specific test situation, expressed in weight of the chemical (mg) per unit of body weight (kg); the toxicant may be fed (oral LD_{50}), applied to the skin (dermal LD_{50}), or administered in the form of vapor (inhalation LD_{50}).

Nonselective herbicide—A chemical that is generally toxic to plants without regard to species. Toxicity may be a function of dosage, method of application, etc.

Noxious weed—A weed specified by law as being especially undesirable, troublesome, and difficult to control; definition varies according to legal interpretations.

Organic matter—That organic fraction of the soil which includes plant and animal residues at various stages of decomposition.

Pellet—A dry formulation of herbicide and other components in discrete particles, usually larger than 10 mm^3.

Pesticide—Any substance or mixture of substances intended for control of insects, rodents, fungi, weeds, and other forms of plant or animal life that are considered to be pests.

Phytotoxic—Injurious or lethal to plants.

Plant growth regulator—A substance used to control or modify plant growth processes without appreciable phytotoxic effect at the dosage applied.

Postemergence (POE)—Applied after emergence of the specified weed or planted crop.

Preemergence (PE)—Applied prior to emergence of the specified weed or planted crop.

Rate—Amount of active ingredient or acid equivalent applied per unit area or other treatment unit.

Residue—That quantity of an herbicide remaining in or on the soil, plant parts, animal tissues, whole organisms, and surfaces.

Selective herbicide—A chemical that is more toxic to some plant species than others.

Spot treatment—Herbicide application over small restricted areas of a whole unit (i.e., treatment of spots or patches of weeds within a larger field).

Spreader—A material which favors or improves the emulsifying, dispersing, spreading, wetting, or other surface-modifying properties of liquids; often used interchangeably with surfactant.

Surfactant—A material which favors or improves the emulsifying, dispersing, spreading, wetting, or other surface-modifying properties of liquids.

Suspension—Mixture containing finely divided particles dispersed in a solid, liquid, or gas.

Systemic herbicide—A compound that is translocated within the plant and has an effect throughout the entire plant system.

Tank-mix combination—Mixing of two or more pesticides or agricultural chemicals in the spray tank at the time of application.

Tolerant—Capable of withstanding effects; for example, grass is tolerant of 2,4-D to the extent that this herbicide can be used selectively to control broad-leaved weeds without killing grass.

Toxicity—The inherent capacity of a substance to produce injury or death.

Translocated herbicide—An herbicide that is moved within the plant; translocated herbicides may be either phloem mobile or xylem mobile, but the term is frequently used in a more restrictive sense to refer to herbicides that are moved in the phloem.

Water dispersible granule—A granular, dust-free wettable powder formulation which, when suspended in water, will require agitation.

Water soluble concentrate (wsc)—Forms a true solution in water (like a water soluble powder), thus requiring little agitation.

Water soluble powder (sp)—Dissolves in water to form a true solution; requires little agitation or mixing.

Weed—A plant growing where it is not desired; plants are considered weeds when they interfere with activities of man or his welfare.

Wettable powder (wp)—A finely divided, dry formulation that can be readily suspended in water.

Wetting agent—Substance which serves to reduce interfacial tensions and causes spray solutions or suspensions to make better contact with treated surfaces (see surfactant).

Pesticide Precautionary Statement

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some states have restrictions on the use of certain pesticides. Check your state and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or state extension specialist to be sure the intended use is still registered.

PROTECT

Use Pesticides Safely

FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

Heidmann, L. J. 1984. Using herbicides for reforestation in the Southwest. USDA Forest Service General Technical Report RM-103, 11 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Site preparation is essential to successfully regenerate conifer stands in the Southwest. Selection of herbicides used to prepare regeneration sites, calibration of equipment, methods of application, and safety are discussed.

Keywords: Herbicides, site prepartaion, reforestation, ponderosa pine

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Forest Service

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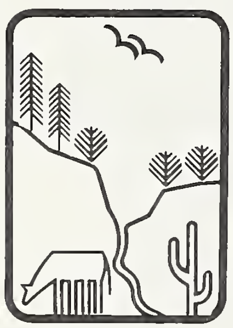
Rocky Mountains



Southwest

Great Plains

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico
Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Rapid City, South Dakota
Tempe, Arizona

*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526